RAINFALL SIMULATION DATA SUMMARY

COLORADO - SAN MIGUEL

U.S. Department of the Interior
Bureau of Land Management
Division of Special Studies
Denver Federal Center
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INTRODUCTION

Field rainfall sumulation studies were begun by the Bureau of Land Management in the summer of 1979 to provide BLM District Office staff with data to help evaluate the effects of Livestock Management Systems on infiltration and erosion. Plot studies were conducted at four field sites: Green Mountain (Wyoming), Prairie Potholes (Montana), Harcuvar Vulture (Arizona), and San Miguel (Colorado). The purpose of this report is to present the data collected from the eight plots on the Monogram soil series at San Miguel (Colorado).

Precipitation, infiltration, runoff and suspended sediment data are presented graphically for individual simulated rainfall events on each plot. Total precipitation (P), total runoff (Q), Q/P ratio, total sediment yield, final infiltration (fc) and pre-run soil moisture are listed for individual runs. Soil series, range condition and vegetation data are listed for individual plots. Summary data are provided for all runs within individual soil series. Means and standard errors are calculated for P, Q/P, fc, and total sediment yield. Linear regression relationships are determined between final infiltration (fc) and total vegetative cover (vegetation, persistent and non-persistent litter) for dry (first) and wet (second) runs. While many variables affect the runoff response of individual plots, it was felt that total vegetative cover was the hydrologic variable most directly affected by livestock grazing. If describable, the fc versus total vegetative cover relationship was felt to be of fundamental interest to watershed managers.

METHODS

Eight 20 X 20 ft plots were located on the Monogram soil series. Plots were selected in cooperation with Montrose District Office personnel. To insure uniform sprinkler grid layouts among plots, a transit was used to

locate the seven sprinkler positions. Each plot was equipped with a 0.4 ft HS flume, a Stevens stage height recorder, and twelve wedge-type raingages.

The rainfall simulator employed was patterned after one developed at Colorado State University (Holland, 1969) and modified by Lusby and Toy (1976). Green (BLM, Division of Special Studies, Denver, CO, unpublished report) subsequently modified the simulator for use on 20 X 20 ft plots. The simulator was designed to provide rainfall intensities of approximately 2 in./hr at 70 percent terminal raindrop velocity with variable raindrop size.

A minimum of two runs were conducted on each plot. A "wet" run generally followed a "dry" run by approximately one day. For each run, rainfall was applied at approximately 2 in./hr for 35-40 minutes. Times to ponding and runoff were recorded. Runoff was sampled at 1 to 2 minute intervals, increasing to 5 minute intervals during the latter part of the run. Laboratory analysis was performed on water samples for suspended sediment concentration.

Soil cores were taken at 2 to 4 locations and at 10 cm increments prior to each run, and were analyzed for water content and dry bulk density.

Vegetative cover was sampled at 100 points along each of two transects on each rainfall simulation plot, using a 10-point frame (Neal et al., 1969). Canopy cover was calculated from first hit data in the canopy. Basal cover data was determined from subsequent basal hit data. Range condition was determined from plant species composition data for each plot using BLM Manual 4412 (1979).

Relative plot elevations were measured by transit and level rod. The data were used to construct plot contour maps by a computer program (USFS, 1975). The contour maps were used to compute plot area and weighted mean plot slope.

SITE DESCRIPTION

The San Miguel plots were located 8 miles southwest of Naturita on Monogram Mesa. The location is a Loamy Foothills range site in the Monogram soil series. Elevation is approximately 7,000 feet. Annual precipitation averages from 15 to 17 inches, with about 40 percent of the precipitation occurring as snow during the winter months. High intensity, short duration convectional storms are common from July through September.

Monogram soils are classified as fine-silty, mixed, Borollic Haplargids. They are deep, well drained soils formed in aeolian material. The surface 3 inches are typically a reddish brown loam. The upper 6 inches of the subsoil are light reddish brown loam. The next 5 inches are a reddish-brown clay loam. Permeability is classified as moderate to a depth of 9 inches. Available water holding capacity is high and effective rooting depth is 60 inches or more.

The Loamy Foothills range site is used for spring, fall and early winter grazing by livestock and wildlife.

RESULTS AND DISCUSSION

Data for individual runs on each plot are presented in Appendix I. Summary data for the eight plots are provided in Table 1. Final infiltration rates on the Monogram soil series averaged 1.19 and 1.05 in./hr for the dry and wet runs respectively. The fairly high infiltration rates in relation to rainfall intensity resulted in average Q/P ratios of 0.12 and 0.27 in./hr for the dry and wet runs respectively.

Average sediment yield from the plots was 11.76 tons/mi^2 for the dry runs and 16.49 tons/mi^2 for the wet runs. Sediment yield data, however, are dependent on many rainfall, soil, slope, and cover variables, and thus should only be considered as an index for a particular site.

An inverse linear relationship was found between final infiltration rate (fc) and total vegetative cover (Fig. 1). The relationship was significant (α = .05) only for the dry runs. The negative slope of the relationship is contrary to what would be expected for the site. Most previous infiltration studies indicate increasing infiltration capacity with increased vegetative cover. There may be several reasons for the contradictory results. First, other variables, including local differences in soils, vegetative composition, and micro-relief also affect infiltration. Secondly, there was not a uniform distribution of percent cover within the range of cover conditions tested. This could have resulted in a spurious regression fit. Thirdly, a number of factors can affect the accuracy and replicability of the experimental technique, including wind, and equipment performance.

The infiltration, runoff and sediment yield values presented are believed to be representative of individual plots under the conditions described. However, the relationships provided should not be extrapolated for general planning purposes.

Table 1. Means, standard errors, n-values and significance of differences between hydrologic values for dry and wet runs on Monogram soil series.

run	P	se(p)	n	Q/P	se(q/p)	n	fc	se(fc)	n	SY*	se(SY)	n
dry	1.08	0.03	9	0.12	0.04	9	1.19	0.10	5	11.76	3.06	6
wet	1.10	0.03	8	0.27	0.06	8	1.05	0.10	7	16.49	2.83	7
T-value of difference	-0.61			-2.10			0.93			-1.14		
significance level of T-value	0.55			0.05			0.38			0.28		

*Sediment Yield

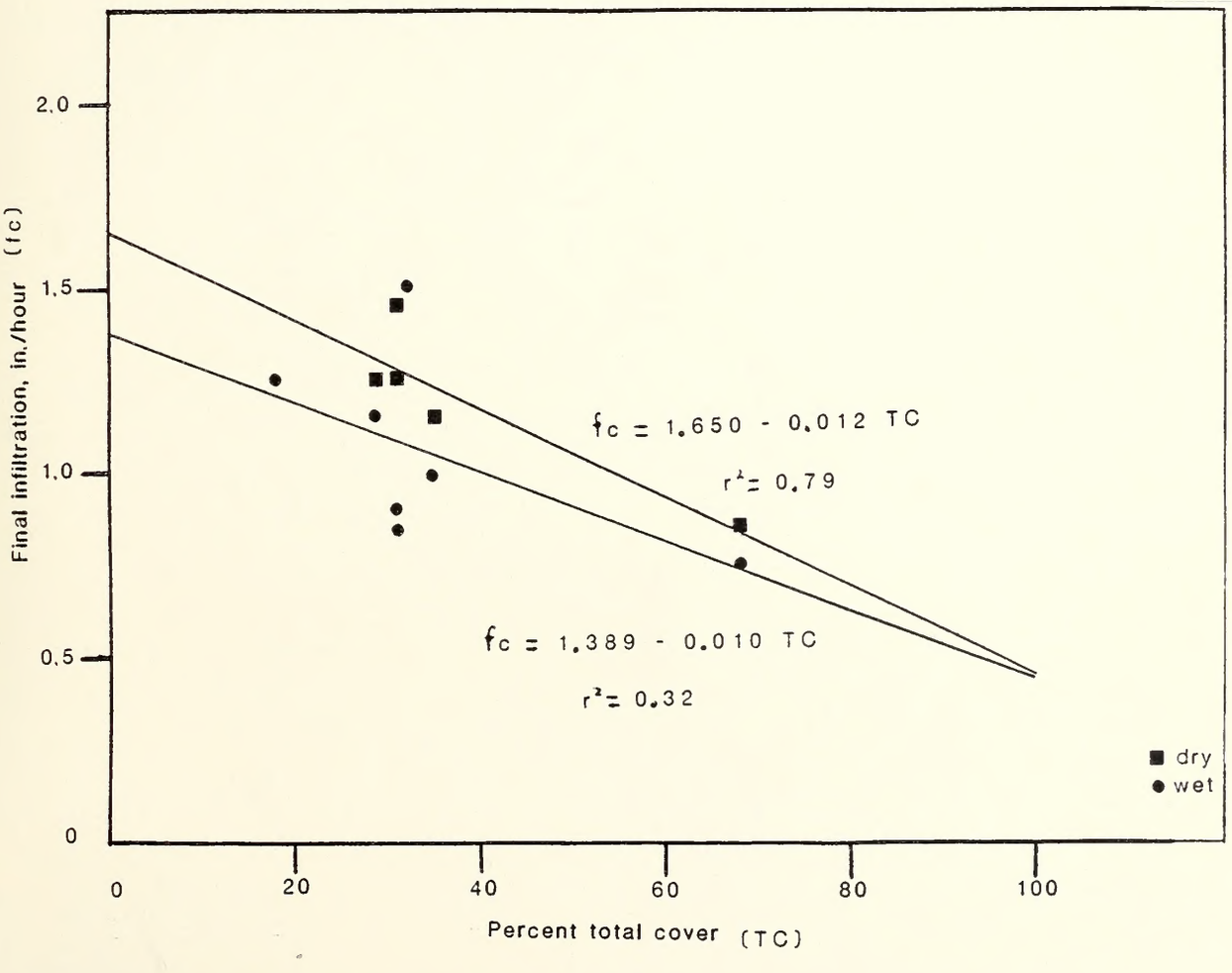


Figure 1. Final infiltration versus percent total vegetative cover for Monogram soil series

LITERATURE CITED

Holland, M.E. 1969. Design testing of rainfall system. Colorado State University Experiment Station, CER 69-70 MEH 21, Fort Collins, CO.

Lusby, G.C., and T.J. Toy. 1976. An evaluation of surface mine spoils area restoration in Wyoming using rainfall simulation. Earth surface processes, Vol. 1, pp. 375-386.

Neal, D.L., R.L. Hubbard, and C.E. Conrad. 1969. A magnetic point frame. J. Range Management, Vol. 13, pp. 251-254.

U.S. Bureau of Land Management. 1979. Manual No. 4412, Physical resource studies.

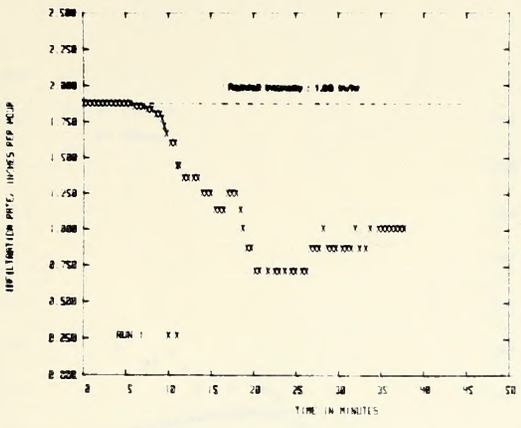
U.S. Forest Service. 1975. FSH 7109.16, Engineering Computer - Application Handbook.

APPENDIX I

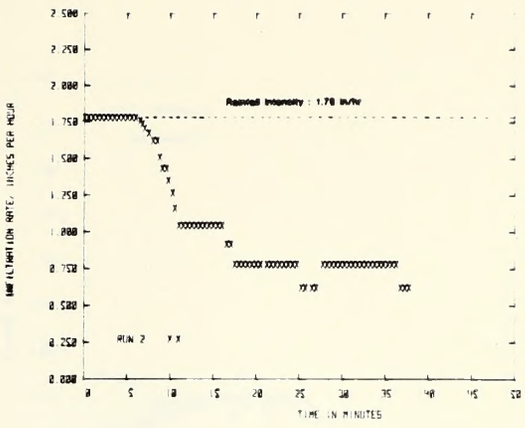
Individual Plot Data

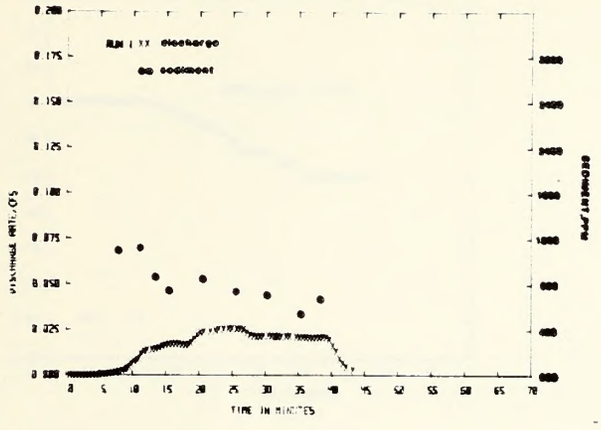
Colorado San Miguel Plot Number 1 Plot Size = 404 ft^2

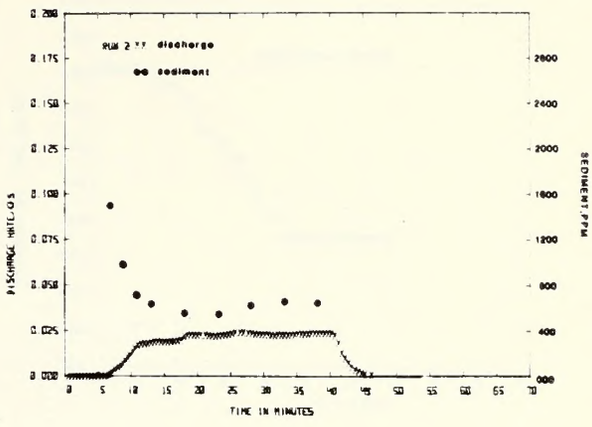
Dry



Wet







HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	7/26/80	0.47	1.19	0.39	19.23	0.85	6.5
wet (2)	7/27/80	0.54	1.13	0.48	17.13	0.75	14.8

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
18	none	4.1	1.37	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	0.0	39.5
Bare	48.5	32.5
NP Litter	51.0	27.5
Per Litter	0.5	0.5
Gravel	0.0	0.0

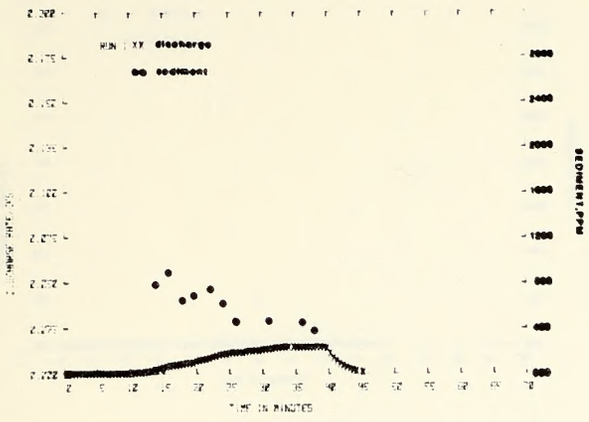
Species Composition

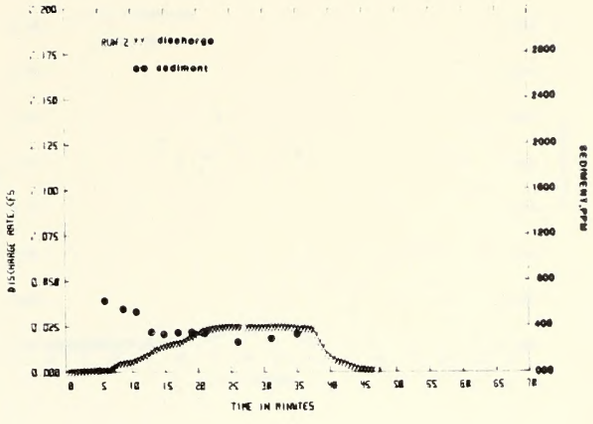
Species	% of Basal Cover	% of Canopy* Cover
Agropyron cristatum	0.0	37.5
Bouteloua gracilis	0.0	1.0
Gutierrezia sarothrae	0.0	1.0

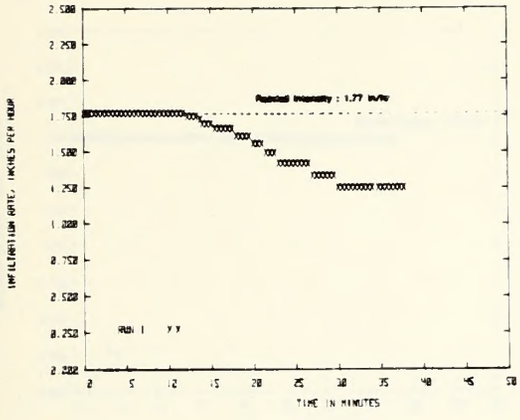
Comment: This run was on site seeded with crested wheat grass.
* Determined from first hit data using a point frame.

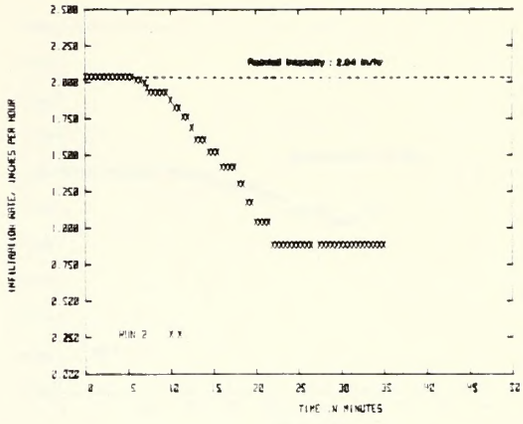
Colorado San Miguel Plot Number 2 Plot Size = 406 ft^2

Dry Wet









HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	7/28/80	0.18	1.12	0.16	4.34	1.25	5.2
wet (2)	7/29/80	0.46	1.19	0.39	6.93	0.90	13.7

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
18	none	2.4	1.34	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	2.0	9.0
Bare	74.0	69.0
NP Litter	19.0	17.0
Per Litter	4.5	4.5
Gravel	0.5	0.5

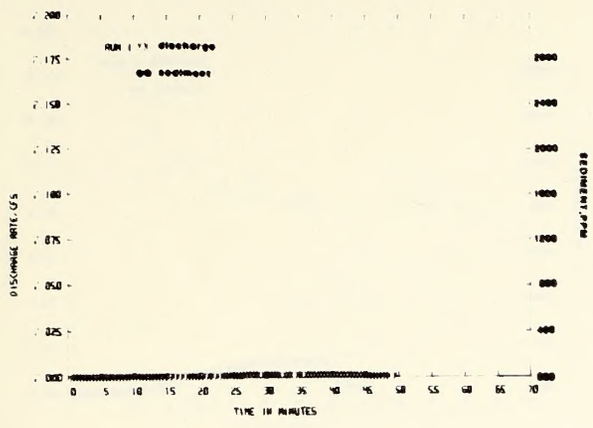
Species Composition

Species	% of Basal Cover	% of Canopy* Cover
Agropyron cristatum	2.0	7.5
Gutierrezia sarothrae	0.0	1.5

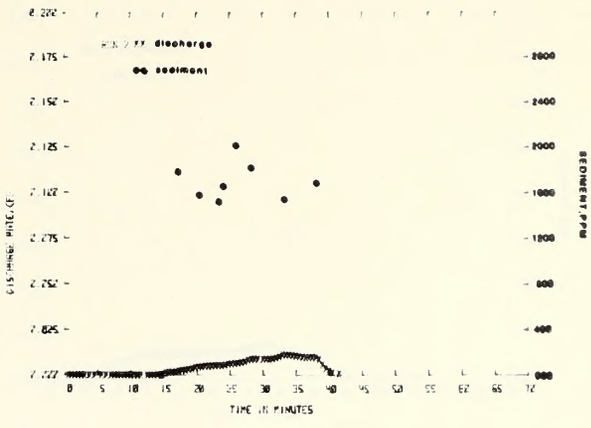
Comment: This run was on site seeded with crested wheat grass.
* Determined from first hit data using a point frame.

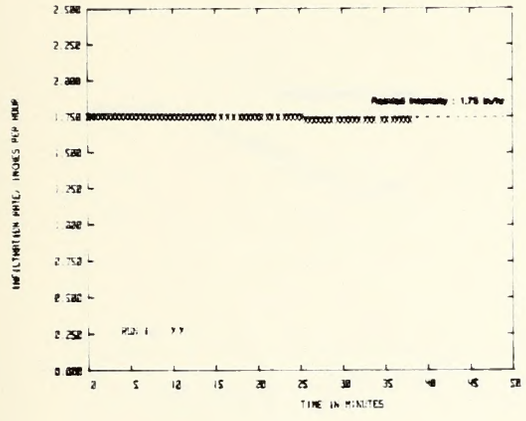
Colorado San Miguel Plot Number 3 Plot Size = 410 ft^2

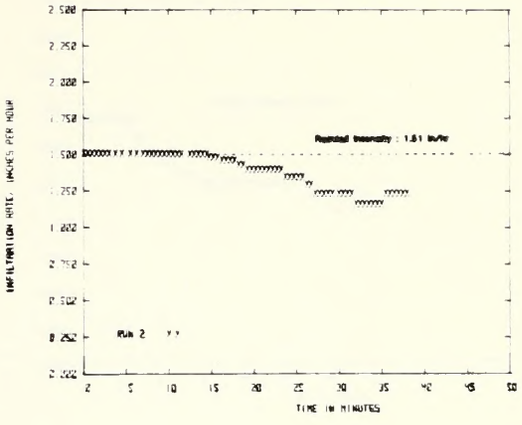
Dry



Wet







HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield $tons/mi^2$	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	8/27/80	0.00	1.11	0.00	--	undetermined	5.1
wet (2)	8/28/80	0.09	0.96	0.09	7.45	1.25	15.1

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
33	25	3.2	1.25	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	6.5	9.0
Bare	83.0	82.0
NP Litter	9.0	7.5
Per Litter	1.5	1.5
Gravel	0.0	0.0

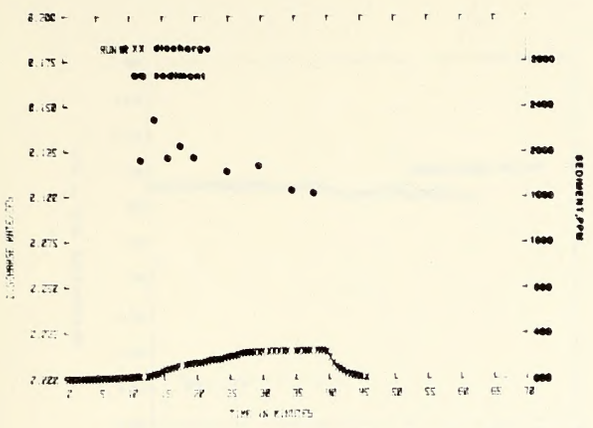
Species Composition

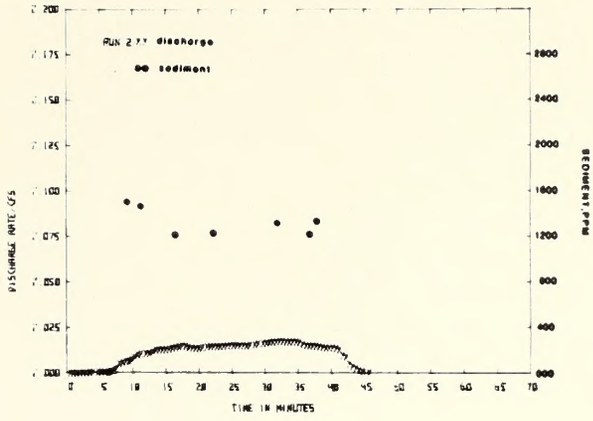
Species	% of Basal Cover	% of Canopy* Cover
Bouteloua gracilis	2.5	2.5
Artemisia tridentata	4.0	6.5

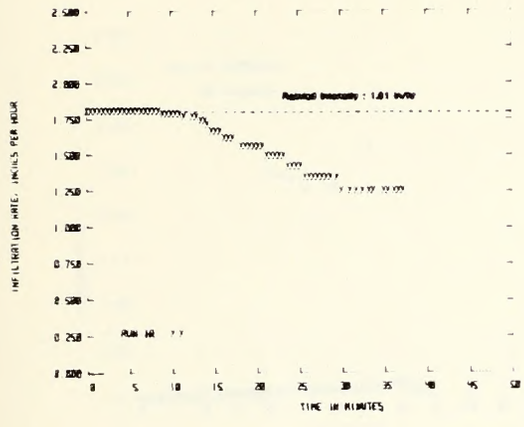
* Determined from first hit data using a point frame.

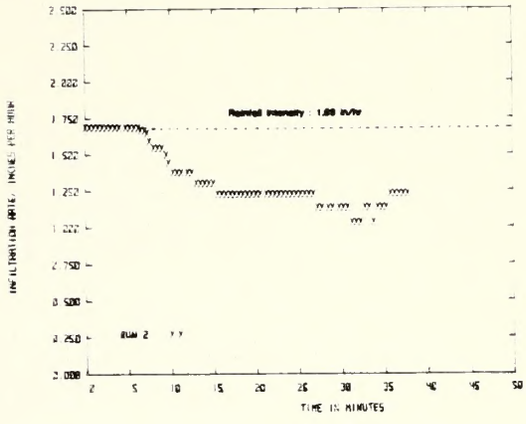
Colorado San Miguel Plot Number 4 Plot Size = 457 ft^2

Dry Wet









HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	8/28/80	0.03	1.04	0.03	2.48	undetermined	4.2
dry (1R)	9/02/80	0.19	1.15	0.17	18.86	1.25	8.8
wet (2)	9/03/80	0.29	1.07	0.27	20.51	1.15	17.8

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
33	29	3.9	1.64	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	6.0	14.0
Bare	72.5	70.0
NP Litter	14.0	9.0
Per Litter	6.0	5.5
Gravel	1.5	1.5

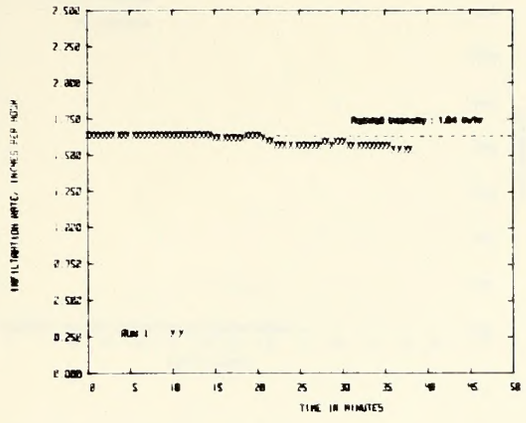
Species Composition

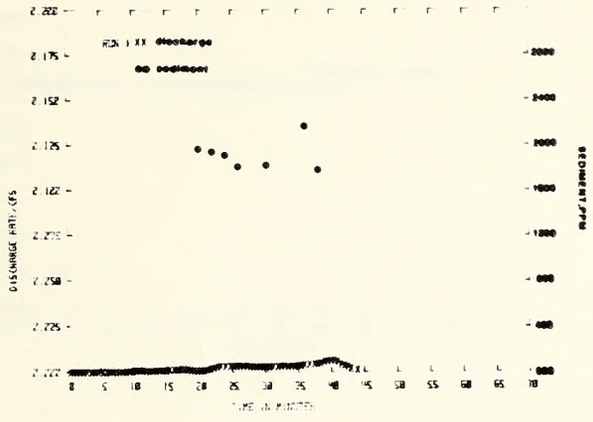
Species	% of Basal Cover	% of Canopy* Cover
Artemisia tridentata	1.0	7.5
Bouteloua cristatum	4.5	5.0
Oryzopsis hymenoides	0.5	1.5

* Determined from first hit data using a point frame.

Colorado San Miguel Plot Number 4 Plot Size = 457 ft^2

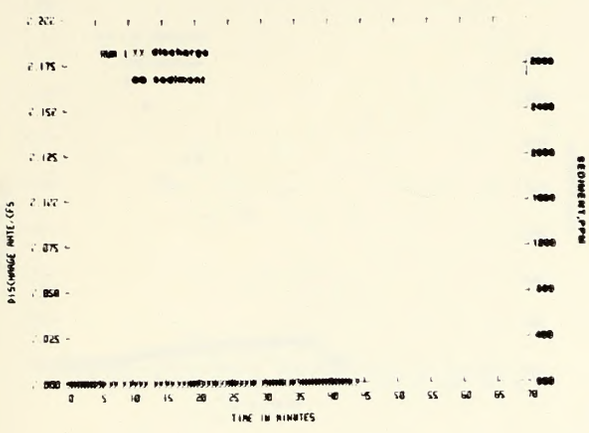
Dry Wet

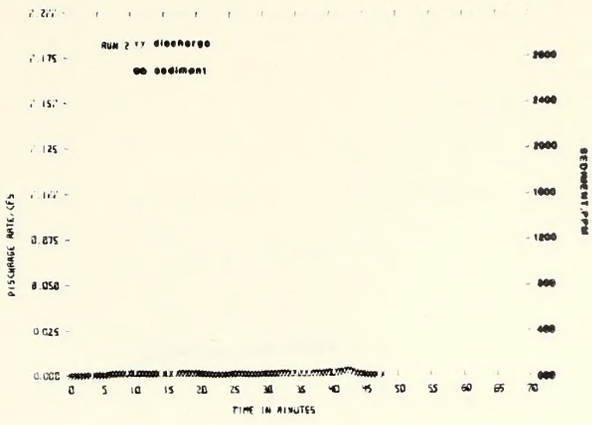


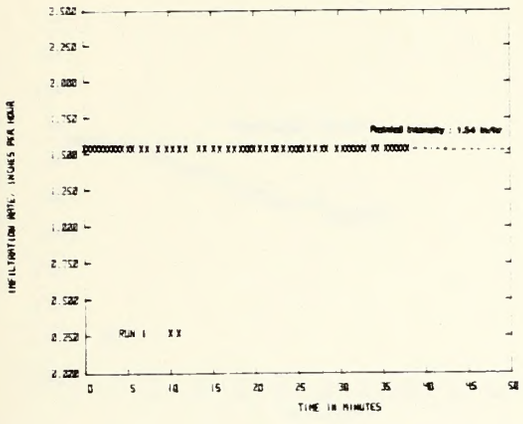


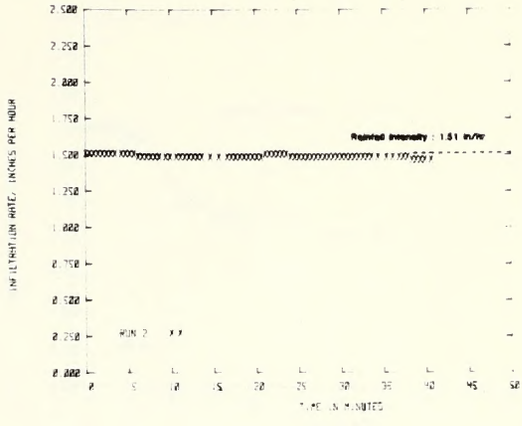
Colorado San Miguel Plot Number 5 Plot Size = 423 ft^2

Dry Wet









HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	9/04/80	0.00	0.98	0.00	--	undetermined	2.4
wet (2)	9/05/80	0.02	1.04	0.02	--	undetermined	12.8

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
20	35	5.6	1.29	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	3.0	11.0
Bare	79.0	74.0
NP Litter	12.0	9.0
Per Litter	6.0	6.0
Gravel	0.0	0.0

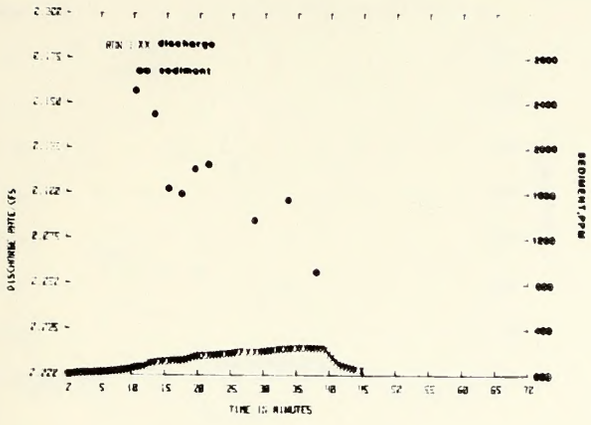
Species Composition

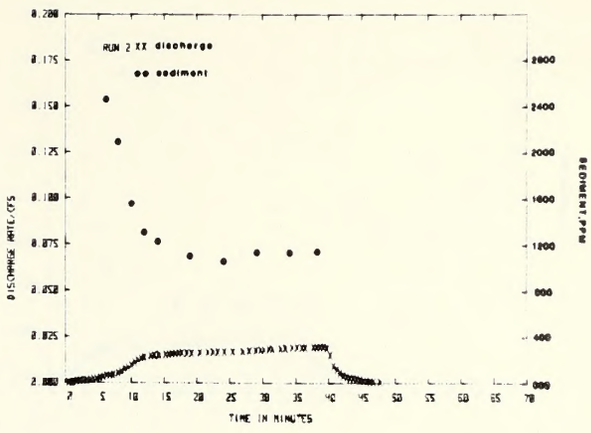
Species	% of Basal Cover	% of Canopy* Cover
Artemisia tridentata	1.5	9.5
Lycopodium	1.5	1.0
Aster	0.0	0.5

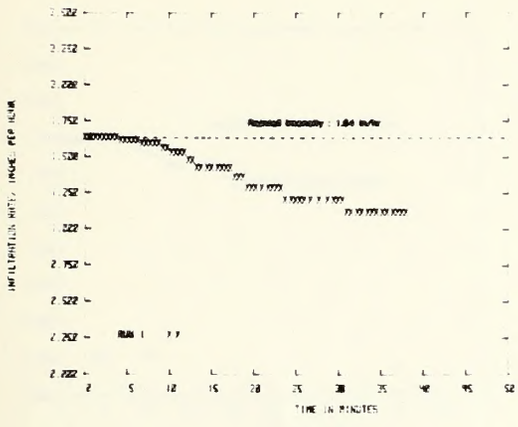
* Determined from first hit data using a point frame.

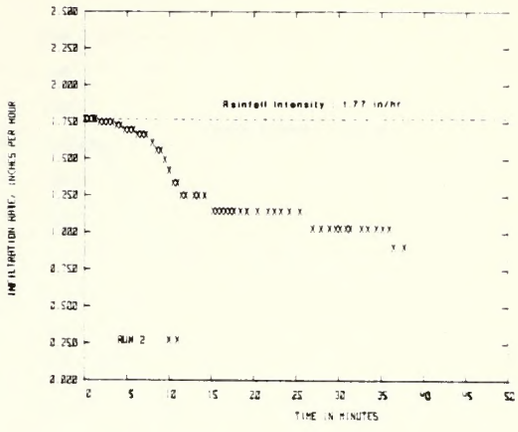
Colorado San Miguel Plot Number 7 Plot Size = 410 ft^2

Dry Wet









HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	9/08/80	0.22	1.04	0.21	16.83	1.15	7.4
wet (2)	9/09/80	0.39	1.12	0.35	27.41	1.00	17.5

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
43	41	4.0	1.26	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	12.0	13.5
Bare	66.5	65.5
NP Litter	13.5	13.0
Per Litter	8.0	8.0
Gravel	0.0	0.0

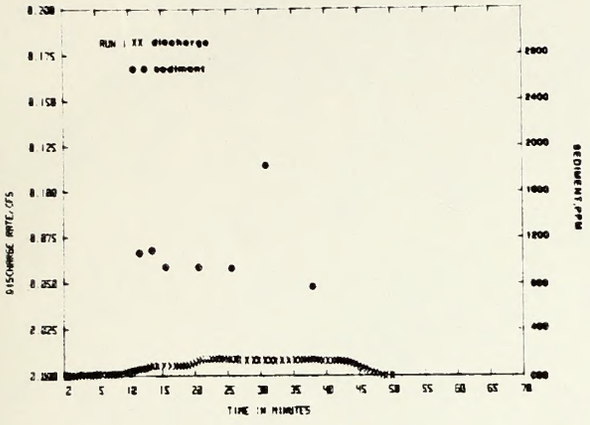
Species Composition

Species	% of Basal Cover	% of Canopy* Cover
Bouteloua gracilis	9.0	9.0
Lycopodium	1.5	1.5
Artemisia tridentata	0.5	2.0
Aster	0.5	0.5
Oryzopsis hymenoides	0.5	0.5

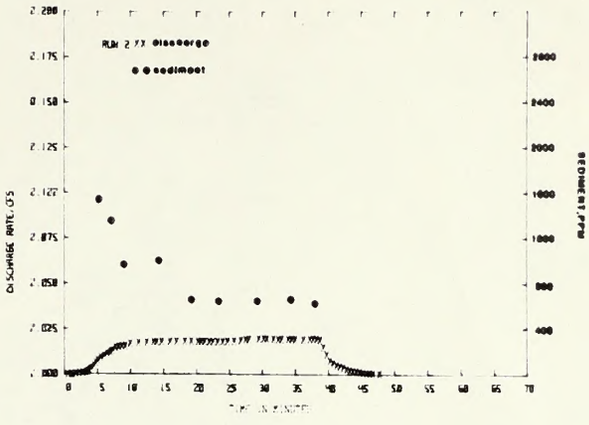
* Determined from first hit data using a point frame.

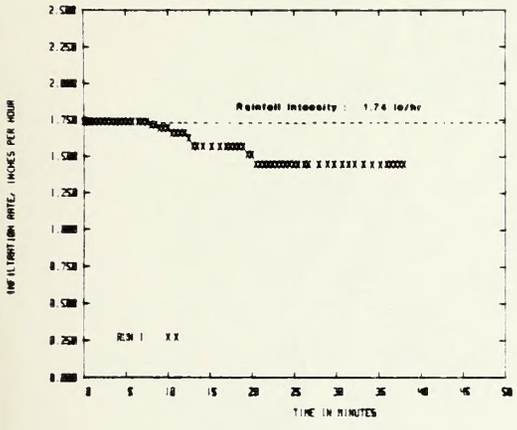
Colorado San Miguel Plot Number 8 Plot Size = 388 ft^2

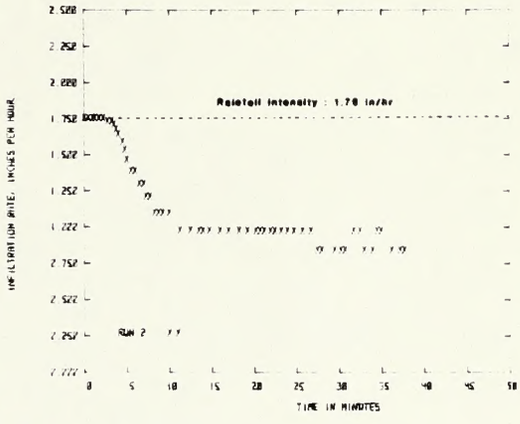
Dry



Wet







HYDROLOGIC DATA

Run	Date	Total Q, in	Total P, in	Q/P	Sediment Yield tons/mi^2	Final Infiltration in/hr	Pre-run % Soil Moisture by weight
dry (1)	9/10/80	0.14	1.10	0.13	8.84	1.45	5.8
wet (2)	9/11/80	0.47	1.11	0.42	21.32	0.85	20.1

SOILS AND VEGETATION

Range Condition	% Coppice Dune	% Slope	Dry Bulk Density gm/cm^3	Soil Series	Texture Class	Range Site
43	34	5.1	1.29	Monogram	loam	Loamy Foothills

Cover Characteristics

Cover	% Basal Cover	% Canopy* Cover
Vegetation	7.5	10.5
Bare	70.0	69.5
NP Litter	19.5	17.0
Per Litter	3.0	3.0
Gravel	0.0	0.0

Species Composition

Species	% of Basal Cover	% of Canopy* Cover
Bouteloua gracilis	4.0	3.5
Eurotia	0.5	0.5
Sitanion hystrix	0.5	0.5
Guiterrezia sarothrae	0.5	0.5
Artemesia tridentata	0.5	4.5
Lycopodium	1.5	1.0

*** Determined from first hit data using a point frame.**